Intelligent Systems: Reasoning and Recognition
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ENSIMAG 2 and MoSIG M1   Second Session Exam - July 2019

Conditions: You have the right to use any notes or written material and a calculator. You may answer questions in English or in French. When appropriate, illustrate your answer with mathematics. Your written answers must be clear and legible. Illegible text will not be graded. Duration: 3 hours.

1) (4 points) Provide a general definition for knowledge. For each of the following types of knowledge, provide a definition, explain how the form of knowledge can be represented, describe tasks for which the form may be used, and explain how the form of knowledge can be acquired: Conceptual knowledge, Declarative knowledge, Procedural knowledge, and Situational knowledge.

2) (6 points) You are presented with a single neuron with two inputs (x_1, x_2) and a single output, $h(\vec{X}) = a$ computed using a sigmoid, $\sigma(z)$. Your network has been initialized with weights $w_1=+0.1$ and $w_2=-0.1$ and $b=0$. Assume a learning rate of $\eta=0.5$.
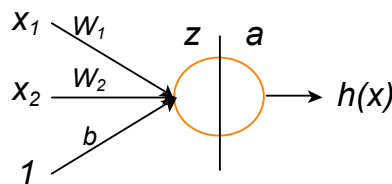

Your network should be trained to recognize the following training data:

m	x_1	x_2	y_m
1	1	1	1
2	1	0	1
3	0	1	0
4	0	0	0

    a) Compute z, and $h(\vec{X}_m)$ for $m=1$.
    b) Compute $\delta_m^{out} = h(\vec{X}_m) - y_m$ for $m=1$
    c) Compute $\delta_m^{(1)}$ for $m=1$
    d) Compute $\Delta w_1, \Delta w_2$, and Δb for $m=1$
    e) Update w_1, w_2, and b for $m=1$.
    f) Will your neuron converge for this training data?

3) (2 points) You are working on a symbol manipulation system where all data elements are triplets of the form:

ID	Data	Next	→	ID	Data	Next
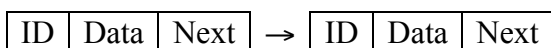
Where ID is a unique ID for each data element, Data is the item stored in the data element, and Next is a pointer to the ID of the next element.

You are given the following template:
```
(deftemplate Node (slot ID)(slot Data)(slot Next))
```

A typical set of facts could be:

```
(deffacts nodes
      (Node (ID 1)(Data This)(Next 2))
      (Node (ID 2)(Data is)(Next 3))
      (Node (ID 3)(Data a)(Next 4))
      (Node (ID 4)(Data 4-Tuple)(Next 5))
)
```

Write a rule to printout sequences of 4 of data elements (4-tuples). A typical output would be:

`4-Tuples: This is a 4-Tuple.`

4) (8 points) You have been hired as a political analyst to work on the political campaign for a referendum. Your job is to identify the sectors of the population for which you can design targeted publicity. For this you prepare a personality quiz for use with Facebook. Each question has a small number of possible responses. You receive M responses. The questions are as follows

1) What is your age? A) 18-29, B) 30-39, C) 40-49, D) 50-59, E) 60 or older
2) How many years of University education do you have? A) none, B) 1 to 2 year, C) 3 to 4 years, D) 5 to 6 years, E) 7 to 8 years, F) more than 8 years.
3) How much do you earn each year? A) < 20K B) 20K to 40K C) >40K to 60K D) >60 to 80K, E) >80 to 100K, F) > 100K.
4) How will you vote in the referendum? A) Yes, B) No, C) Undecided, D) I will not vote.

a) Explain how to use a ratio of histograms to predict the response to question 4 as a function of the answers to questions 1, 2 and 3. How many people must be polled before you can trust the results.

b) Explain how to estimate and use a multivariate Gaussian Density to predict the response to question 4 as a function of the answers to questions 1, 2 and 3. What is the probability of error?

c) Explain how to use a Kernel Density Estimator to predict the response to question 5 as a function of the answers to questions 1, 2 and 3.

d) Explain how to use the EM algorithm to discover categories of voters who are undecided given their responses to questions 1 to 3. How would you initialize the algorithm? How would you determine the number of categories?

Look-up Table of Sigmoid function.

z	f(z)	z	f(z)	z	f(z)	z	f(z)	z	f(z)
0	0.500	1	0.731	2	0.881	3	0.953	4	0.982
0.1	0.525	1.1	0.750	2.1	0.891	3.1	0.957	4.1	0.984
0.2	0.550	1.2	0.769	2.2	0.900	3.2	0.961	4.2	0.985
0.3	0.574	1.3	0.786	2.3	0.909	3.3	0.964	4.3	0.987
0.4	0.599	1.4	0.802	2.4	0.917	3.4	0.968	4.4	0.988
0.5	0.622	1.5	0.818	2.5	0.924	3.5	0.971	4.5	0.989
0.6	0.646	1.6	0.832	2.6	0.931	3.6	0.973	4.6	0.990
0.7	0.668	1.7	0.846	2.7	0.937	3.7	0.976	4.7	0.991
0.8	0.690	1.8	0.858	2.8	0.943	3.8	0.978	4.8	0.992
0.9	0.711	1.9	0.870	2.9	0.948	3.9	0.980	4.9	0.993